

# Bone mineral density in healthy Kuwaiti women

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## Abstract

**Objective** This study aimed to measure bone mineral density (BMD) of the lumbar spine and femur regions in healthy adult Kuwaiti women, and to evaluate the influence of body size on BMD results.

**Methods** Bone mass measurement was performed by dual-energy X-ray absorptiometry at the lumbar spine (L2–L4) and femur (four regions) of healthy ambulatory Kuwaiti females aged between 20 and 80 years. Body size measurements and a detailed questionnaire on past medical and gynecologic history, as well as lifestyle factors, were administered to all subjects. After excluding those with apparent or suggested abnormalities affecting bone mass, only 805 women from 4,887 were included and served as the target subjects.

**Results** The spine BMD values for Kuwaiti women up to 69 years old were lower than their US counterparts; the peak value was established in the fifth decade. Femur neck BMD was relatively stable up to menopause. Spine osteoporosis was prevalent among 10% of the subjects, compared with 4% in the femoral neck. Regression analysis revealed that each kilogram of body weight has a change of 0.3% in

premenopausal women and 0.5–0.6% in the older group. In multiple regressions that included the three factors (height, weight and age), the effect of age superseded that of weight in the older group of women, where there was a detrimental annual effect on spine and femur (neck and total hip) BMD by 0.9%, while each kilogram of body weight had a constructive effect by 0.4 and 0.3%. In the premenopausal women, the positive effect of 1 kg of body weight was equivalent to about 1 year of aging in the trochanter region and half a year in the total hip region.

**Conclusion** The BMD value of healthy Kuwaiti women tend to be lower than the US reference at the lumbar spine in all age groups but showed higher values for femur neck only in the age group of late 30s through 60 years. Weight has a stronger effect on BMD than does the height. The prevalence of osteoporosis in the lumbar spine was more than double that in the femur neck in postmenopausal women.

**Keywords** Bone mineral density · DXA · Kuwait · Osteoporosis

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## Introduction

Osteoporosis is a disorder characterized by compromised bone strength predisposing to an increased risk of fractures. Bone strength reflects the integration of two main features: bone density and bone quality [1].

It is in fact a public health problem affecting one third of women in the USA and it is of increasing social and economic importance as the size of the aging population continues to grow [2].

According to the World Health Organization, osteoporosis is defined as a bone mass density 2.5 SD (T-score  $\leq -2.5$ ) or more below peak bone mass (PBM) as measured by dual

energy X-ray absorptiometry (DXA). PBM itself is defined as the average maximum bone mass achieved by young healthy sex- and race-matched adults. On the other hand, osteopenia is defined as a BMD between 1.0 and 2.5 SD below PBM (T-score between  $-1$  and  $-2.5$ ) [3].

There has been rapid development of DXA for measuring bone mineral density (BMD in  $\text{g}/\text{cm}^2$ ) in the axial skeleton for diagnosing osteopenia and osteoporosis, for ascertaining fracture risk and for monitoring treatment [4]. These systems contain sets of BMD reference data for different populations, as appropriate reference values are critical for clinical evaluation of normality and manufacturers usually provide these values in their densitometers [5].

However, it is well known that there are significant differences in BMD between age groups of different sexes and geographical areas [6–13]. For example, BMD values in black women exceed those in white women; values in white women exceed those in Asian women; values in white women in the United States/Northern Europe are greater than those in Lebanese and Saudi Arabian women [6, 8, 10, 12]. Accordingly, bone mineral density measurement should be related to normal values specific for the patient's race and gender. Several studies were conducted in the local region to measure BMD in different populations, such as Lebanon [2, 10], Saudi Arabia [6, 8] and a preliminary study in Kuwait [12]. Thus, the objectives of this study were to measure BMD at the lumbar spine and femur in healthy adult Kuwaiti women, to assess the prevalence of osteoporosis and to evaluate the influence of body size especially weight on BMD results.

## Materials and methods

### Sample selection

All measurements were made on ambulatory Kuwaiti women. Eight hundred and five healthy subjects, aged 20–79 years, were selected from 4,887 Kuwaiti females referred for bone mass density measurements in the department of Nuclear Medicine at Al-Amiri Hospital in the period from July 2001 till October 2005.

### Exclusive criteria

Women with extremities of weight who weighted less than the fifth percentile (45 kg) or more than the 95 percentile (85 kg) were excluded from the study. Any woman with a current or past medical history that might influence the BMD measurements was also excluded. These cases were: prolonged secondary amenorrhea; connective tissue disease, such as rheumatoid arthritis; history of endocrine or metabolic disorders, such as thyrotoxicosis, hypothyroidism

or diabetes mellitus; major chronic diseases (intestinal, liver, kidney, heart) or cancer; history of radiation therapy or chemotherapy; history of oophorectomy or hysterectomy before menopause; intake of medications that affects bone metabolism, such as steroids, hormone replacement therapy, biphosphonates, selective estrogen receptor modulator (SERM), thyroxin, anticoagulants, calcium or vitamin D. Accordingly, any adult Kuwaiti female who had no past medical history of any problem listed above was legible for the study after getting her verbal consent.

### Anthropometric measurements, lifestyle and reproduction factors

A face-to-face interview was conducted with each selected legible female. The interview questionnaire included socio-demographic information (e.g., age, age of menopause). Questions related to their smoking status, caffeine consumption, dairy products consumption and practicing exercise were included. Reproductive history covered parity and lactation period. Subjects were weighed on an electrical scale to the nearest half kilogram. Height was measured using a stadiometer to the nearest half centimeter. Body mass index (BMI) was calculated as  $\text{weight (kg)}/\text{height (m)}^2$ .

### Bone density measurements

BMD of the lumbar spine (L2-L4) and bilateral femur (neck, Ward's triangle, trochanter, and total hip) in postero-anterior projection was measured using one DXA machine (Lunar Prodigy densitometer) at the Nuclear Medicine Department in Al-Amiri Hospital. The Middle East reference database provided by the manufacturer was being used for calculating T-scores for establishing the prevalence of osteopenia and osteoporosis.

### Quality assurance of densitometer

Machine calibration was done daily. Spine phantoms were measured daily as recommended by the DXA machine manufacturer and the mean coefficient of variation {CV%; expressed as  $[\text{standard deviation (SD)}/\text{mean}] \times 100$  of all daily replicate measurements of the spine phantom for duration of the study} was less than 1%. The in vivo precision error (CV %) were 1.5% for the lumbar spine, 2% for the femoral neck, and 1.8% for the total hip.

### Data analysis

The collected data were entered and analyzed using the Statistical Package for Social Sciences (SPSS) version 13. Mean, SD, simple and multiple linear regression analysis were performed to detect the association between the

**Table 1** Height (cm), weight (kg), and BMI (kg/m<sup>2</sup>) of normal Kuwaiti women

Age in years	n	Height		Weight		BMI	
		Mean	SD	Mean	SD	Mean	SD
20–29	15	159.6	5.7	68.0	7.9	26.8	3.3
30–39	38	157.5	5.9	67.1	9.3	27.1	3.9
40–49	279	156.3	6.1	70.1	9.2	28.7	3.7
50–59	298	154.6	5.7	70.8	8.3	29.7	3.9
60–69	125	151.1	7.5	70.4	9.3	31.0	4.6
70–79	50	149.8	6.8	66.5	11.4	29.7	5.1
20–79	805	154.6	6.6	70.0	9.1	29.4	4.1

different variables. The level of significance was  $P<0.05$  and confidence interval (CI) was 95%.

## Results

The study was conducted among 805 healthy Kuwaiti women selected from an original 4,887 Kuwaiti females referred for bone mass density measurements after applying the exclusion criteria listed in the [Materials and methods](#) section. Only 1.1% of them were currently smokers; more than one third of them (35.3%) consumed about 2 cups of caffeine/day. Less than one half of them (43%) consumed around 1.5 cups of dairy products/day, but only 15% practiced exercise for about 1.5 h/week. Parity was experienced by 85% of the subjects with an average of four times; and 35.8% of them experienced lactation for a mean of 8 months.

Table 1 shows the heights, weights and BMI by decade. The average height and weight were 155 cm  $\pm$  7 and 70 kg  $\pm$  9, respectively. The mean BMI was 29 kg/m<sup>2</sup>  $\pm$  4, where about 40% of the women were overweight (BMI 25–29.9) and 44.3% were obese (BMI  $\geq$  30). The mean spine and femoral region (neck and total hip) BMD in different decades are shown in Table 2.

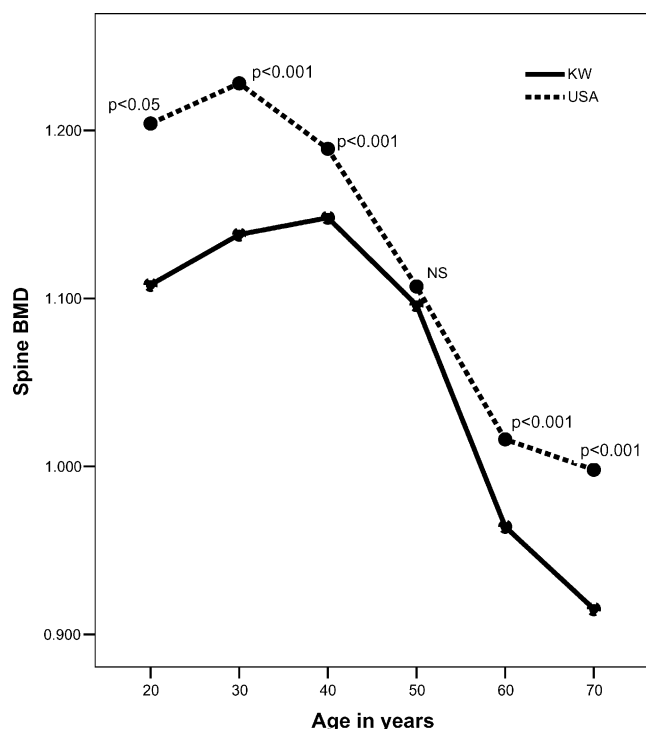
Spine BMD showed a very slight increase to reach its highest value in the fifth decade. The femur neck BMD was relatively stable from 20 to 49 years. BMD values in the present study were comparable with previous study data in the USA [14] (Figs. 1, 2). The spine BMD values for the Kuwaiti sample were significantly lower than the American average in almost all age groups but for the age group 50–59 years. Similarly, the data for the femur neck BMD of young women (20–29 years) followed the spine BMD pattern, but the difference from the corresponding US females was insignificant. In the ages from late 30s through almost 60 years, the BMD in the Kuwaiti females showed significantly higher values than their USA counterparts, except in the age group from 60 to 69 years where the difference was insignificant, and returned back significantly to the former picture after age 60.

The prevalence of osteopenia and osteoporosis in the women aged from 50 to 79 years was demonstrated in Table 3. The table indicates that spine and femur neck osteopenia showed a very close distribution (27% and 25%, respectively), while spine osteoporosis was more than double the prevalence in the femur neck region (10% and 4%, respectively).

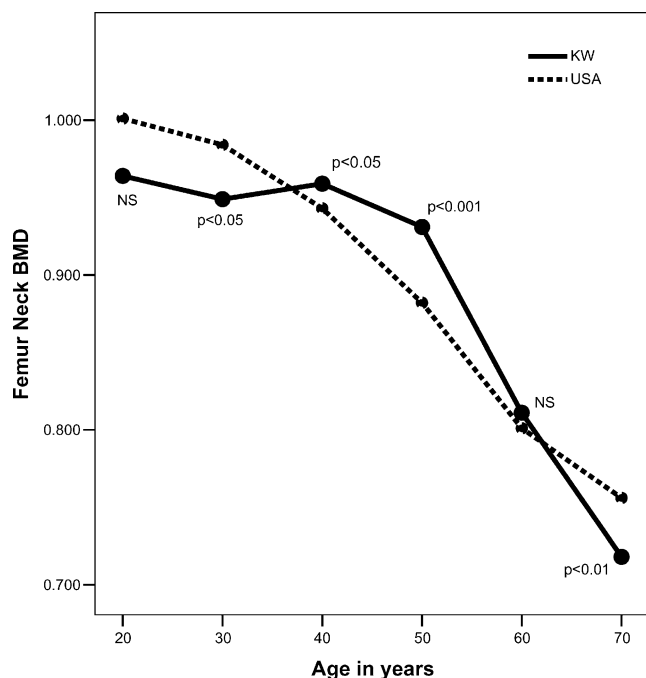
The influence of height and weight on BMD was investigated by regression analysis, as illustrated in Tables 4 and 5. The positive effect of height was more apparent in the postmenopausal women than in the premenopausal group; each centimeter of height had a significant change in BMD by 0.2–0.3% (spine and femur neck only, respectively) in premenopausal women compared with 0.4–0.5% (spine, femur neck and Ward's regions) in older women. The effect of weight was stronger than height, where each kilogram of body weight had a change of 0.3% in premenopausal women and 0.5–0.6% in the older group. In the multiple regressions that included height and weight, the latter had about 3- to 5-times greater effect on BMD than the former. Multiple regressions of height, weight and age for premenopausal women (20–49 years) and postmen-

**Table 2** Age-specific values of bone mineral density in posteroanterior (PA) spine and femur (neck and total hip)

Age (years)	n	PA spine (L2-L4)			Femur					
		Mean	SD	95% CI	Neck			Total hip		
					Mean	SD	95% CI	Mean	SD	95% CI
20–29	15	1.108	0.15	1.027–1.189	0.964	0.11	0.906–1.022	0.988	0.13	0.916–1.060
30–39	38	1.138	0.12	1.099–1.177	0.945	0.09	0.920–0.978	0.974	0.08	0.947–1.001
40–49	279	1.148	0.15	1.130–1.165	0.959	0.11	0.945–0.972	1.013	0.12	0.999–1.027
50–59	298	1.096	0.16	1.078–1.114	0.931	0.13	0.916–0.946	1.005	0.14	0.989–1.021
60–69	125	0.964	0.16	0.934–0.993	0.811	0.11	0.791–0.831	0.893	0.12	0.871–0.915
70–79	50	0.915	0.16	0.868–0.961	0.717	0.10	0.689–0.746	0.802	0.13	0.766–0.839
20–79	805	1.085	0.17	1.072–1.096	0.910	0.14	0.900–0.920	0.976	0.14	0.966–0.986



**Fig. 1** Spine BMD according to age in healthy adult Kuwaiti women and USA women (NS not significant)



**Fig. 2** Femur neck BMD according to age in healthy adult Kuwaiti women and USA women (NS not significant)

**Table 3** Prevalence of osteoporosis (T-score of  $<-2.5$  SD) and osteopenia (T-score  $>-2.5$  SD and  $<-1$  SD) in Kuwaiti women 50–79 years ( $n=473$ )

Age	Spine		Femur neck	
	Osteopenia <i>n</i> (%)	Osteoporosis <i>n</i> (%)	Osteopenia <i>n</i> (%)	Osteoporosis <i>n</i> (%)
50–59	65 (13.7)	9 (1.9)	44 (9.3)	0 (0.0)
60–69	44 (9.3)	22 (4.7)	50 (10.6)	8 (1.7)
70–79	18 (3.8)	16 (3.4)	24 (5.1)	11 (2.3)
50–79	127 (26.8)	47 (9.9)	118 (24.9)	19 (4.0)

opausal women (50–79 years), height did not demonstrate any significant influence on the BMD of any region.

Age was a significant constructive factor only for femur trochanter and total hip regions in the premenopausal group, where BMD increased annually by 0.4 and 0.3%, respectively. However, it demonstrated a highly significant detrimental effect in all bone regions in the postmenopausal women. In this latter group, BMD decreased an average of 1% annually, except for the trochanter where the rate was 0.7%. In the multiple regressions that included the three factors (height, weight and age), the effect of age superseded that of weight in the older group of women, where there was a detrimental annual effect on spine and femur (neck and total hip) BMD by 0.9%, while each kilogram of body weight had a constructive effect by 0.4 and 0.3%. In the premenopausal women, the effect of 1 kg of body weight was equivalent to about 1 year of aging in the trochanter region and half a year in the total hip region.

## Discussion

This report outlined BMD values from a group of ambulatory healthy Kuwaiti females with exclusion of extreme body weights. Subjects were also excluded on the basis of medical conditions or medication known to affect bone mass density.

The present study revealed that PBM was achieved in the fifth decade for the spine and total hip, and in the third decade for the femur neck. This was similar to the Saudi results on healthy Saudi females [6, 8]. Other studies showed PBM in females at the third decade of life irrespective to bone regions [12, 14], and at the fourth decade [6]. These differences in PBM density at maturity may be accounted for by differences in race and lifestyle. Asian women also have lighter bones which were partially attributed to their low body weight [15]. In addition, the age at which PBM is attained is suggested to be different among skeletal sites as well, occurring earlier in the femoral region than in the spine region [16].

An important finding was that the mean value for spine BMD in all age groups was lower than those reported from

**Table 4** Regression of BMD for spine and femur regions ( $n=332$ ) on height ( $HT$ ), weight ( $WT$ ), and age in Kuwaiti women 20–49 years

Region		$r$	$P$
Spine (L2-L4)	$0.687+0.003 HT$	0.12	0.01
Femur (neck)	$0.495+0.003 HT$	0.16	0.002
Femur (Ward's $\Delta$ )	$0.557+0.002 HT$	0.08	NS
Femur (trochanter)	$0.828+0.000 HT$	-0.01	NS
Femur (total)	$0.898+0.001 HT$	0.04	NS
Spine (L2-L4)	$0.960+0.003 WT$	0.17	0.001
Femur (neck)	$0.733+0.003 WT$	0.27	<0.0001
Femur (Ward's $\Delta$ )	$0.597+0.003 WT$	0.22	<0.0001
Femur (trochanter)	$0.568+0.003 WT$	0.29	<0.0001
Femur (total)	$0.725+0.004 WT$	0.32	<0.0001
Spine (L2-L4)	$1.059+0.002 Age$	0.08	NS
Femur (neck)	$0.931+0.001 Age$	0.03	NS
Femur (Ward's $\Delta$ )	$0.838 - 0.001 Age$	-0.02	NS
Femur (trochanter)	$0.618+0.004 Age$	0.22	<0.0001
Femur (total)	$0.892+0.003 Age$	0.13	0.01
Spine (L2-L4)	$0.564+0.002 HT+0.002 WT+0.002 Age$	0.19	0.004
Femur (neck)	$0.477+0.002 HT+0.003 WT+0.000 Age$	0.28	<0.0001
Femur (Ward's $\Delta$ )	$0.634+0.005 HT+0.003 WT - 0.001 Age$	0.22	0.001
Femur (trochanter)	$0.609 - 0.001 HT+0.003 WT+0.003 Age$	0.35	<0.0001
Femur (total)	$0.791 - 0.001 HT +0.004 WT+0.002 Age$	0.33	<0.0001

their USA counterparts [14], although the average body weight and BMI of the Kuwaiti women were higher. This could be possibly due to the effect of low vitamin D (25-OHD) and how much it might contribute to low bone mass density. Vitamin D insufficiency or deficiency is not an uncommon disease in the Middle East region as reported in countries such as Jordan [17], Lebanon [18] and Kuwait [19]. Although the sunshine is available all year around, the level of serum vitamin D (25-OHD) was found to be low

(below 20 pmole/l) in 43 out of 50 (86%) young healthy veiled Kuwaiti females. This was attributed to the heavy clothing worn and avoidance of exposure to sun [19]. Other contributing factors to low bone density should be also considered such as lack of exercise, inappropriate nutrition (low in calcium and vitamin D), multiparity and lactation.

Another finding demonstrated in Fig. 2 was a peculiar BMD pattern for the femur neck region. The mean BMD values for females from late 30s to almost 60 years of age

**Table 5** Regression of BMD for spine and femur regions ( $n=473$ ) on height ( $HT$ ), weight ( $WT$ ), and age in Kuwaiti women 50–79 years

Region		( $r$ )	( $P$ )
Spine (L2-L4)	$0.359+0.004 HT$	0.17	<0.0001
Femur (neck)	$0.160+0.005 HT$	0.21	<0.0001
Femur (Ward's $\Delta$ )	$0.157+0.004 HT$	0.15	0.001
Femur (trochanter)	$0.481+0.002 HT$	0.09	0.02
Femur (total)	$0.425+0.003 HT$	0.15	0.001
Spine (L2-L4)	$0.617+0.006 WT$	0.31	<0.0001
Femur (neck)	$0.508+0.005 WT$	0.33	<0.0001
Femur (Ward's $\Delta$ )	$0.366+0.005 WT$	0.27	<0.0001
Femur (trochanter)	$0.426+0.005 WT$	0.33	<0.0001
Femur (total)	$0.529+0.006 WT$	0.36	<0.0001
Spine (L2-L4)	$1.608 - 0.01 Age$	-0.43	<0.0001
Femur (neck)	$1.464 - 0.01 Age$	-0.55	<0.0001
Femur (Ward's $\Delta$ )	$1.368 - 0.011 Age$	-0.55	<0.0001
Femur (trochanter)	$1.160 - 0.007 Age$	-0.39	<0.0001
Femur (total)	$1.520 - 0.01 Age$	-0.51	<0.0001
Spine (L2-L4)	$1.173+0.000 HT+0.005 WT - 0.009 Age$	0.50	<0.0001
Femur (neck)	$1.051+0.001 HT+0.004 WT - 0.009 Age$	0.60	<0.0001
Femur (Ward's $\Delta$ )	$1.238 - 0.001 HT+0.003 WT - 0.011 Age$	0.56	<0.0001
Femur (trochanter)	$1.023 - 0.001 HT+0.004 WT - 0.006 Age$	0.48	<0.0001
Femur (total)	$1.261 - 0.001 HT+0.005 WT - 0.009 Age$	0.58	<0.0001



were higher than their USA counterparts, while BMD values for the two extremes of age (20–29 years) and (over 60 years) were lower. Similar findings were reported by Hammoudeh et al. [20], in the spine and total femur in Qatari women when they were compared with Caucasians. Also, there was no diminution of axial BMD values in the 30- to 39-year-old women in either spine or femur neck. This was well demonstrated in longitudinal studies in premenopausal women [21].

Moreover, our findings showed that bone changes were more rapid within the first 10 years post menopause than in subsequent periods particularly for spine BMD, others found it more accelerated within the first 3–5 years after menopause [22, 23]. This might explain the higher prevalence of spine osteoporosis over the femur neck osteoporosis.

As reported by others also, spinal bone loss slowed down by age 60, but femoral bone loss continued [23]. It is well known that trabecular bone loss proceeds from young adulthood onward, whereas compact bone loss seems not to occur until menopause [24, 25].

The effect of body weight on the BMD changes was very comprehensible in our results. It showed that each change of 1 kg was associated with a change of 0.3–0.4% in BMD of the spine and femur in younger women and the weight effect was larger in our sample for women over age 50 years (0.5–0.6%). This is in concordance with the findings of earlier studies [26], where they found that body weight profoundly influenced the percentage of abnormality. The earlier studies showed that each change of 1 kg was associated with a change of 0.3–0.4% in BMD of the spine or femur neck. Others have shown that postmenopausal bone loss is minimal in over weight women and accelerated in the thinnest women [27].

The study also revealed the positive role of height on BMD changes. In the younger group of women each 1 cm of height showed a significant change of 0.3% of BMD in the spine and femur neck only. However the significant effect of height was obvious in BMD of all skeletal regions in older women with a change between 0.2–0.5%.

Of the 473 women in our sample between 50 and 79 years of age, 47 (9.9%) were below the conventional –2.5 SD threshold of osteoporosis in the spine and 19 (4.0%) in the femur neck using the Middle East reference database provided by the manufacturer. In comparison with a healthy Lebanese population, the mean femur neck BMD values were significantly higher in Kuwaiti females in the age range 30–59 years ( $P<0.01$ , 0.0001 and 0.0001, respectively), while spine BMD values were also significantly higher among Kuwaiti females in the age group 40–49 years ( $P<0.01$ ), but the reverse was observed in Lebanese females in the age group 50–59 years ( $P<0.0001$ ). In addition, the prevalence of spine and femur neck osteoporosis were

significantly ( $P<0.0001$ ) higher in the spine (11%) of female Lebanese and lower in the femoral neck (2%) ( $P=0.5$ ) using Lebanese reference data [10]. This could be referred to the higher prevalence of obesity in the Kuwaiti females relative to their Lebanese counterparts. This prevalence also might be changed when using a different reference data base. On the other hand, presence of other uncommon risk factors for osteoporosis that were not included in the study should not be neglected as a limitation of the present study.

## Conclusion

The BMD values of healthy Kuwaiti women have had a propensity to be lower than the US reference at the lumbar spine in all age groups, but showed higher values for femur neck only in the age group of late 30s through 60 years. Weight demonstrated a stronger effect on BMD than did height. The prevalence of osteoporosis in the lumbar spine was more than double that in the femur neck in postmenopausal women. These results might differ when using a US database.

The findings suggested that Kuwaiti BMD values might be different from USA values to warrant a separate reference sample with which to compare individuals for the purpose of early detection of osteoporosis and osteopenia.

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